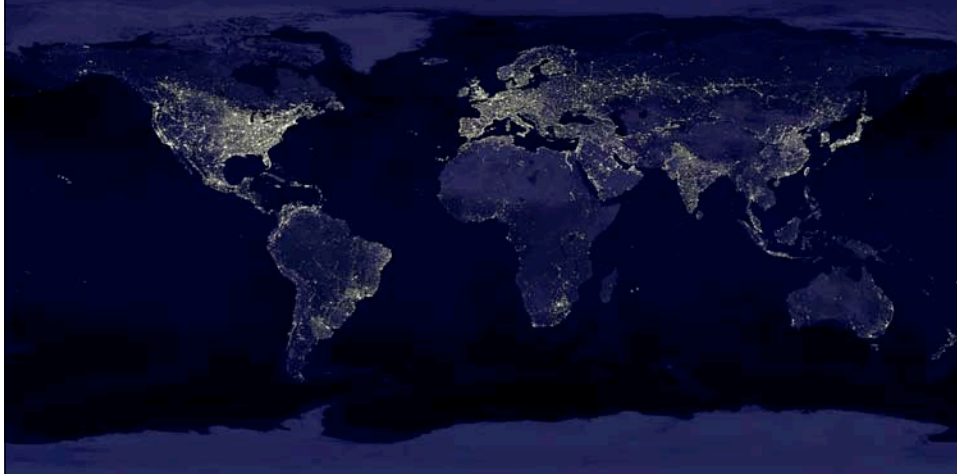


## **Alternatives to Fuel-based Lighting in Rural Areas of Developing Countries**



**Evan Mills, Ph.D.**

Lawrence Berkeley National Laboratory

Presented to GROCC - Reykjavik, Iceland, 13 June 2006

**“We will make electricity so cheap  
that only the rich will burn candles”**

- Thomas Edison



As of 2000: in the developing world, 14% of  
urban households and 49% of rural  
households had no electricity ...

Photo: Evan Mills ©

... In fact, there are more non-electrified households today than the total number in Edison's time.

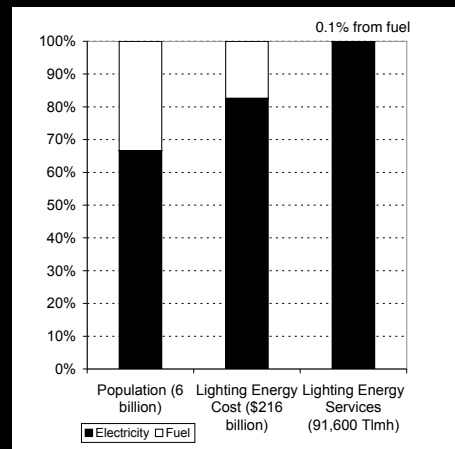


Ghana

Photo: Rick Wilk

## Lighting Inequities

Although one in three people obtain light with kerosene and other fuels - **paying \$40 billion/year** - about 20% of global lighting costs, they receive only 0.1% of the resulting lighting energy services

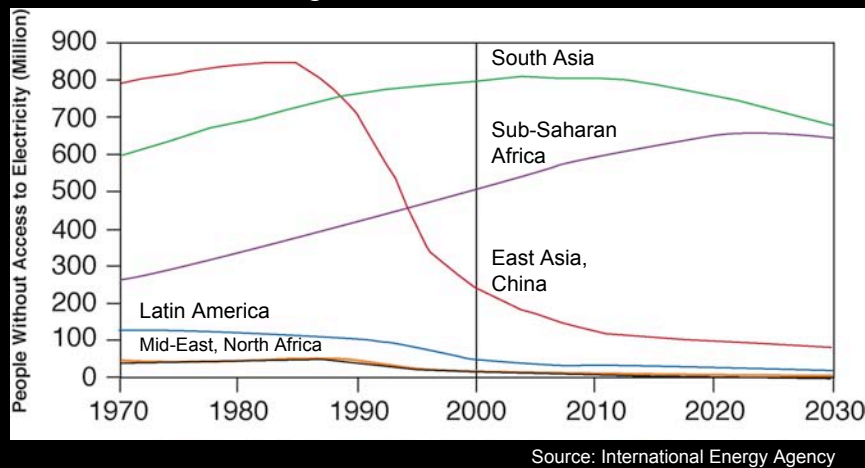


LBNL Analysis

**Other issues: literacy, safety, women's work, indoor air quality, subsidy, scarcity, price volatility**

# Non-electrified Population is Falling Only 0.4%/year

- Excluding China, population is growing faster than electrification, e.g. 4-x faster in Sub-Saharan Africa



## Electrification: Not always effective



Yunnan  
China

Photos: Evan Mills ©

## The \$40B Lighting Market at the Bottom of the Pyramid

GNI/per capita		Global Population	Total Income	
US\$ 26,490	High Income	0.9 Billion	US\$ 25 Trillion	Lighting Market Mostly Developed
US\$ 5,110	Upper Middle Income	0.3 Billion	US\$ 1.7 Trillion	
US\$ 1,400	Lower Middle Income	2.4 Billion	US\$ 3.4 Trillion	Lighting Market Mostly Undeveloped
US\$ 430	Low Income	2.5 Billion	US\$ 1 Trillion	

Note: Based on the "The Fortune at the Bottom of the Pyramid", C.K. Prahalad and World Bank Development Indicators, 2004

## Greenhouse Gas Emissions



- Per Lantern:  
100 kg CO<sub>2</sub>/year
  - 40-times as much per unit of light as incandescent lamp;
  - 180- times as much as compact fluorescent lamp
- Globally:  
190 million tonnes CO<sub>2</sub>/year
  - would be 8th most-emitting "country"

## Small & Medium Enterprises (SMEs)



India: street vendor



Tanzania: night market

Photos: Evan Mills ©

## Wick Lanterns



Photos: Evan Mills ©

## Merchant (Candle)

Bhutan



Photo: Evan Mills ©

## Market (Candles)

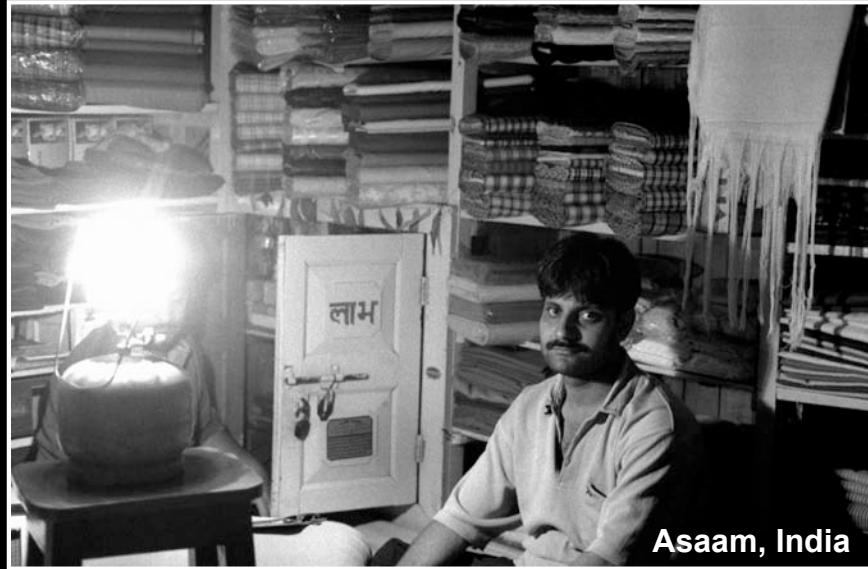
Cambodia



Photo: Evan Mills ©



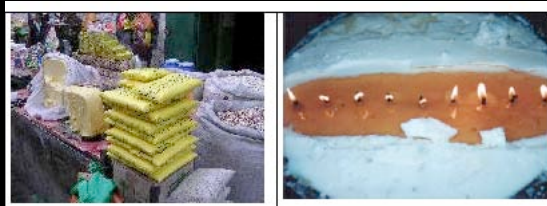
## Textile Seller (Propane Mantle Lamp)



Asaam, India

Photo: Evan Mills ©

## Yak Butter



Nepal



Yunnan, China

Photos: Evan Mills ©

## Whale and Seal Oil



Photo: Evan Mills ©

## Fuel Wood is Widely Used for Lighting





## The Burden of Fuel-based Light



Huangshan, China



India: propane lamp

Photos: Evan Mills ©

## Kitchen: 2% Recommended Level



China

Photo: Evan Mills ©

# Refugee Camps



Photo: Salgado

- Classroom light levels as low as 2% of western standards
- Teachers grading homework with light levels 1% of western standards



Kenya (Kibera Slum)



Tanzania (Periurban Area)

Photos: Evan Mills ©

## “Electrification” (Yunnan, China)



Photos: Evan Mills ©

## Traditional Solar-Fluorescent Systems Have only 0.2% Market Penetration (and less at the bottom of the pyramid)



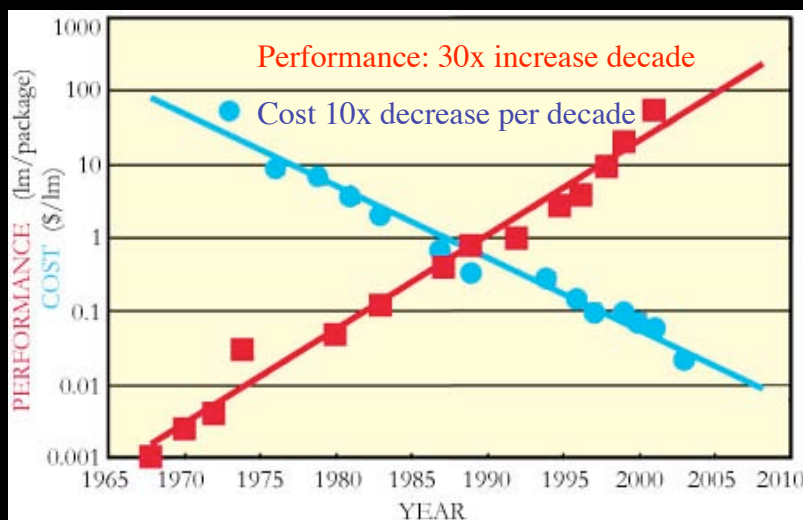
Photo: Evan Mills ©

## White Light-emitting Diodes (“LEDs”)

- Efficient
- Long life
- Low voltage
- Directional
- Portable
- Rugged



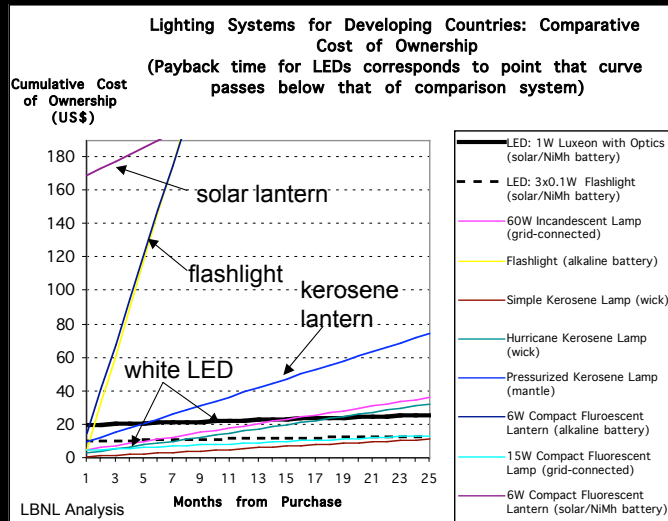
## White LEDs: Rising Light Output; Falling Cost



Source: Lumileds

# Total Cost of Ownership: LED Payback is 1 month to 2 years

- 10-100x  
a hurricane  
lantern's  
light output
- Cost of  
saved oil:  
\$15/bbl



## Stanford + IDEO + LBNL (and others from Silicon Valley)





“The 93,000,000 mile extension cord”

Form  
&  
Function

million points of light



## Productive Uses



Tanzania: shoe seller - flame [left]; 1-watt white LED [right]

Photos: Evan Mills ©

“I can see the money!”



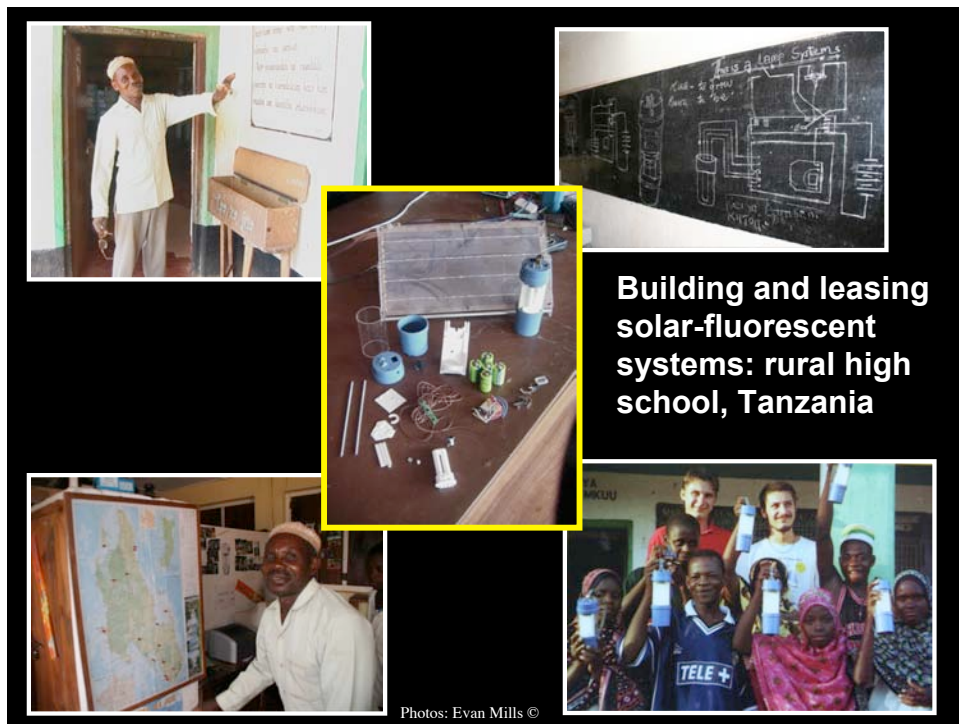
Kenya: vegetable stand in Kibera slum

Photo: Evan Mills ©

## Proposed GROCC Demonstration

- *Interactive* design - end users as co-developers
- Insight into lighting structure and behavior
- Understanding productive uses
- Synergisms with the mobile phone market & a diversity of SMEs
- Innovative distribution & assembly strategies





## More Information

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<http://eetd.lbl.gov/emills>

